JSC- 29095
PART 1

ALPHA MAGNETIC SPECTROMETER - 02 (AMS-02) EXPERIMENT/PAYLOAD INTEGRATION HARDWARE (PIH) INTERFACES

Space and Life Sciences Directorate
Flight Projects Division

June, 2002

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

ALPHA MAGNETIC SPECTROMETER – 02 (AMS-02) EXPERIMENT/PAYLOAD INTEGRATION HARDWARE (PIH) INTERFACES

Prepared By:

_____
T. K. MEHTA
AMS PAYLOAD ENGINEER, LMSO

Reviewed By:

_____
ROSS A. HAROLD
AMS MECHANICAL DESIGN LEAD ENGINEER, LMSO

_____
TRENT MARTIN
AMS DEPUTY PROJ. MGR, LMSO

Approved By:

_____
KEN BOLLWEG
AMS PROJECT MANAGER, LMSO

_____
J. R. BATES
AMS MISSION MANAGER,
PLANNING & INTEGRATION BRANCH, NASA/JSC

_____
S. S. C. TING
AMS PRINCIPAL INVESTIGATOR, MIT

PAGE 1 OF 1

DOCUMENT CHANGE/REVISION LOG

CHANGE/ REVISION	DATE	DESCRIPTION OF CHANGE	PAGES AFFECTED
Baseline	June, 2002	Baseline	All

PREFACE

This Interface Control Document (ICD) represents the interface agreement between the Alpha Magnetic Spectrometer – 02 (AMS-02) Experiment and the Payload Integration Hardware (PIH) for the version of the payload to be operated on the International Space Station (ISS) for approximately three (3) years beginning with installation on the ISS during Utilization Flight 4 (UF4), presently designated as ISS-26-UF4 and shuttle flight STS-130. The mission baseline is 1000 days of operational time (24,000 hours) in full deep space view.

A precursor flight (AMS-01) was accomplished on the Space Shuttle during the STS-91 flight and was addressed in an ICD similar to this document. The AMS on STS-91 was operated for approximately 8.5 days during the flight.

TABLE OF CONTENTS

LIST OF TABLES

PAGE

ACRONYMS AND ABBREVIATIONS

ACC	Anti-coincidence Counter
ACOP	AMS Crew Operations Post
AMS	Alpha Magnetic Spectrometer
CCP	Configuration Control Panel
CDR	Critical Design Review
CIR	Cargo Integration Review
CIRN	European Organization for Nuclear Research
CMP	Configuration Management Plan
COFR	Certificate Of Flight Readiness
CR/DIR	Change Request/Directive
CSR	Customer Support Room
DDRS	Digital Data Recording System
DOE	Department Of Energy
EBCS	External Berthing Cue System
ECAL	Electromagnetic Calorimeter
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EVA	Extravehicular Activity
FOR	Flight Operations Review
FPSR	Flight Planning And Stowage Review
FRGF	Flight Releasable Grapple Fixture
FRR	Flight Readiness Review
GFE	Government Furnished Equipment
GHE	Ground Handling Equipment
GSE	Ground Support Equipment
GSRP	Ground Safety Review Panel
HDBK	Handbook
ICD	Interface Control Document
IDD	Interface Design Document

ACRONYMS AND ABBREVIATIONS (CONTINUED)

IDRD	Increment Definition And Requirements Document
IPT	Integrated Product Team
ISS	International Space Station
ISSP	International Space Station Program
JIS	Joint Integrated Simulations
JISWG	Joint Integrated Simulations Working Group
JOIP	Joint Operations Interface Procedure
JSC	Lyndon B. Johnson Space Center
KHB	KSC Handbook
KSC	John F. Kennedy Space Center
LEPS	Low Energy Particle Shield
LMSO	Lockheed Martin Space Operations
MAPTIS	Materials And Processes Technology Information System
MCC	Mission Control Center OR Monitoring and Control Computers
MDL	Master Document List
MIL	Military
MIP	Mission Integration Plan
MIT	Massachusetts Institute Of Technology
M/OD	Meteoroid and Orbital Debris
MSFC	Marshall Space Flight Center
MUA	Material Usage Agreements
NASA	National Aeronautics And Space Administration
NBL	Neutral Buoyancy Laboratory
NHB	National Aeronautics And Space Administration Handbook
NSTS	National Space Transportation System
OIU	Orbiter Interface Unit
OMRS	Operations And Maintenance Requirements And Specifications

ACRONYMS AND ABBREVIATIONS (CONTINUED)

PAS	Payload Attach System
PDA	Payload Disconnect Assembly
PDR	Preliminary Design Review
PFR	Portable Foot Restraint
PIB	Planning And Integration Branch
PIH	Payload Integration Hardware
PMP	Project Management Plan
POCC	Payload Operations Control Center
POIC	Payload Operations Integration Center
POWG	Payload Operations Working Group
PRD	Program Requirements Document
PSRP	Payload Safety Review Panel
PSS	Primary Support Stand
PVGF	Power Video Grapple Fixture
RICH	Ring Imaging Cherenkov Counter
ROEU	Remotely Operated Electrical Umbilical
SRMS	Shuttle Remote Manipulator System
SSP	Space Station Program
SSRMS	Space Station Remote Manipulator System
STA	Structural Test Article
STD	Standards
STE	Special Test Equipment
STS	Space Transportation System
TAS	Tracker Assembly System
TBD	To Be Determined
TCS	Thermal Control System
TIM	Technical Interchange Meetings
TOF	Time Of Flight
TRD	Transition Radiation Detector
UMA	Umbilical Mechanism Assembly
USS	Unique Support Structure

VAR	Verification Acceptance Review
VC	Vacuum Case
Vol	Volume
WAD	Work Authorization Document
WIF	Worksite Interface

1.0 INTRODUCTION

1.1 GENERAL

In this Interface Control Document (ICD) “AMS” will refer to the total complement of activities, hardware, software, test, integration and operation of the Alpha Magnetic Spectrometer – 02 (AMS-02). The flight hardware is referred to as the “AMS Payload” and is comprised of two parts: the “AMS Experiment” provided by the international AMS Experiment Collaboration and the “AMS Payload Integration Hardware (PIH)” provided by the JSC Planning and Integration Branch (PIB) of the Flight Projects Division with the support of Lockheed Martin Space Operations (LMSO).

This ICD pertains only to the version of the AMS (AMS-02) that will be installed and operated on the International Space Station (ISS). The acronym “AMS-01” will be used for references to the precursor flight version that flew on STS-91.

This ICD will be issued in two Parts. Part 1 will be the “Management” document and Part 2 will be the “Technical” document. This is the Management document and will be referred to herein as “this document” or “Part 1 of this ICD.”

1.2 AMS PAYLOAD DESCRIPTION

The AMS Experiment is a state-of-the-art particle physics detector containing a large, cryogenic superfluid helium superconducting magnet that will be designed, constructed, tested and operated by an international team organized under United States Department of Energy (DOE) sponsorship. The AMS Experiment will use the unique environment of space to advance knowledge of the universe and potentially lead to a clearer understanding of the universe’s origin. Specifically, the science objectives of the AMS are to search for cosmic sources of antimatter (i.e., anti-helium or heavier elements) and dark matter.

1.3 DOCUMENT PURPOSE

This document defines the management roles and responsibilities, the technical activities, interfaces, list of deliverables, and schedule requirements to accomplish the AMS Experiment to PIH integration, launch, flight operations, post landing operations, and deintegration activities.

2.0 DOCUMENTATION

The reference documents that form part of this ICD are contained in the AMS Master Document List (MDL), JSC-29741 (LMSEAT-33971). These documents are applicable to AMS as specified herein or in other AMS documentation. The document revision that is in effect on the date of approval of this ICD shall apply unless otherwise noted. A notation of “Current issue” after date of approval indicates all future changes and revisions are applicable to the AMS project. In the event of conflict between this ICD and any other documents invoked herein, the contents of this ICD shall govern.

3.0 MANAGEMENT RESPONSIBILITIES

The responsibility for assuring definition, control, implementation, and accomplishment of the activities identified and agreed to in this document is vested with the JSC PIB for all AMS Payload integration activities and with the Massachusetts Institute of Technology (MIT) for the AMS Experiment.

3.1 JOINT RESPONSIBILITIES

The PIB and MIT will provide the data products and support the necessary analytical and physical integration activities and reviews as defined in the master schedule in Section 11.0. The PIB and MIT will support Technical Interchange Meetings (TIMs) with the technical personnel responsible for the accomplishment of the integration tasks. The interfaces and associated activities include, but are not limited to, management, avionics, structures, thermal, flight planning, flight operations, ground operations, and safety.

3.1.1 Documentation

Part 1 and Part 2 of this ICD will be jointly approved by designated representatives of PIB and MIT. Configuration control will be initiated upon signature approval. The PIB will maintain configuration control of this document in accordance with JSC 27542, “Alpha Magnetic Spectrometer (AMS) Configuration Management Plan.” All proposed changes to the ICD shall be submitted by PIB Change Request/Directive (CR/DIR) and jointly approved by the PIB and MIT.

3.1.2 Order of Precedence

In the event of inconsistency between documentation, unless otherwise expressly provided in this agreement, such inconsistency will be resolved by giving precedence in the following order:

a. Part 1 of this ICD
b. Part 2 of this ICD
c. Other Documentation

3.2 NASA-JSC PIB RESPONSIBILITIES

The PIB is responsible for providing all AMS Payload integration activities consisting of flight and ground safety, analytical and physical integration, development of AMS PIH [i.e. Unique Support Structure – 02 (USS-02), Cryomagnet Vacuum Case (VC), Digital Data Recording System – 02 (DDRS-02) etc.], development of AMS Payload software requirements, and AMS Payload hardware/software verification. In addition, the PIB will provide Ground Support Equipment (GSE) and Ground Handling Equipment (GHE) to support ground processing for the USS-02, VC and DDRS-02.

All activities and deliverables will be performed in accordance with the AMS-02 Master Schedule which is updated periodically by the PIB. The PIB is responsible for identifying to MIT all integration issues that may affect MIT responsibilities and will include a plan to resolve the issues.

The PIB is responsible for the development of the AMS Verification Plan which is part of the “Alpha Magnetic Spectrometer (AMS-02) Attached Payload Hardware Interface Control Document” (SSP 57213), the AMS Verification Data Sheet Package Closures and the Flight and Ground Safety Data Packages. The PIB is responsible for coordinating the development of SSP 57113, “Payload Integration Agreement for Alpha Magnetic Spectrometer – 02”; SSP 57113A, “Payload Integration Agreement Increment Addendum for Alpha Magnetic Spectrometer – 02 (AMS-02)”; SSP57213, “Alpha Magnetic Spectrometer (AMS-02) Attached Payload Hardware Interface Control Document”; and SSP 57313, “Alpha Magnetic Spectrometer (AMS) Software Interface Control Document” with the ISS. The PIB is responsible for the coordinating the inclusion of AMS requirements into the Increment Definition and Requirements Documents (IDRDs) and IDRD Annexes for the Planning Periods involved. The PIB is responsible for coordinating the inclusion of AMS requirements into the Mission Integration Plan (MIPs), MIP A-level ICD and MIP Annexes for the Shuttle flights involved. The PIB will provide AMS Payload integration support throughout the integration/ operation/ deintegration periods. The PIB is responsible for providing mission support activities at the JSC Payload Operations Control Center (POCC) and AMS Payload representation at the JSC Customer Support Room (CSR).

The PIB will convene and conduct a Preliminary Design Review (PDR) and a Critical Design Review (CDR) for the integration activities and hardware developed by the PIB.

The PIB will support International Space Station Program (ISSP) and Space Shuttle Program (SSP) meetings and reviews as required to support the AMS integration process. The meetings and reviews will include but are not limited to the following:

a. Cargo Integration Review (CIR)
b. Payload Flight Safety Reviews
c. Payload Ground Safety Reviews
d. Flight Planning and Stowage Reviews (FPSR)
e. Verification Acceptance Review (VAR)
f. Flight Operations Review (FOR)
g. Flight Readiness Review (FRR)
h. Space Shuttle Integrated Product Team (IPT) meetings
i. Launch Package Manager's IPT meetings

3.3 MIT RESPONSIBILITIES

MIT is responsible for the coordination and concurrence of all the AMS collaborators involved in the definition, design, development, fabrication, assembly, test, checkout, and operations of the AMS Payload. All activities and deliverables will be performed in accordance with the AMS-02 Master Schedule which is updated periodically by the PIB.

MIT will provide notification to the PIB whenever AMS Experiment changes affect Part 1 and/or Part 2 of this ICD. MIT is responsible for identifying to the PIB all AMS Experiment issues that may affect PIB responsibilities and will include a plan to resolve the issues. Also, MIT is responsible for the design, development, and delivery of the AMS Experiment including Experiment GHE and GSE. MIT will provide integration inputs and the software for the DDRS-02.

MIT is completely responsible for all issues related to the AMS Crew Operations Post (ACOP). MIT will provide all integration, documentation, hardware, software, training, mission operations, and planning associated with the ACOP as this is not part of the NASA responsibilities.

4.0 MISSION OPERATIONS

4.1 CARGO ELEMENT WEIGHTS

The PIB will publish weight and mass properties data for the AMS Payload in appropriate ISSP and SSP documentation utilizing MIT and PIH inputs. The PIH inputs will include items supplied by the SSP and/or ISSP and integrated into the AMS Payload by the PIB. Control weights (and actual weights, when available) for the AMS Experiment, USS-02, VC and other integration hardware will be used.

4.2 AMS PAYLOAD DATA INPUTS

MIT will provide inputs to the PIB to allow the PIB to generate, or support generation of, the necessary ISSP and SSP integration documentation. The PIB will coordinate with and provide support to MIT to complete data inputs as required.

The PIB will provide and maintain configuration control of the interface data agreements contained in Part 1 and Part 2 of this ICD for all the AMS interfaces.

4.3 OPERATIONAL REQUIREMENTS AND CONSTRAINTS

4.3.1 Ascent

The Super-Fluid Helium (SFHe) tank nominal vent will be opened during the ascent phase. MIT will provide detailed requirements for the PIB related to this vent operation. The PIB will ensure that these operation requirements are relayed to the appropriate SSP documentation.

4.3.2 On-Orbit Pre-Dock

The AMS Payload is to be activated on-orbit pre-dock in the Space Shuttle for an abbreviated checkout. (This activation will not include charging of the AMS superconducting magnet.) If the checkout is not successful, a real time decision will be made by MIT to return the hardware or transfer it to the ISS. Thermal conditioning of the payload will also be performed during this period.

4.3.3 On-Orbit Dock

If the pre-dock checkout is successful, the AMS Payload will be de-activated and transferred to the ISS. The payload bay hardware will be transferred to its assigned location on the ISS truss via the Shuttle Remote Manipulator System (SRMS) and the Space Station Remote Manipulator System (SSRMS). Some of the hardware stowed in the Orbiter pressurized volume will be transferred to the ISS pressurized volume. The AMS Payload will then be activated for operation. If anomalies are detected prior to departure of the Space Shuttle and the Space Shuttle timeline will allow it, a real time decision will be made by MIT to return the hardware or leave it on the ISS.

Prior to descent, the AMS-02 external hardware will be deactivated for transfer to the Space Shuttle. It will then be transferred to the Space Shuttle payload bay via the SSRMS and the SRMS. The AMS-02 hardware located in the ISS pressurized volume will also be deactivated, transferred to the Space Shuttle and stowed for return. All hardware will remain deactivated until transferred to the PIB representative after landing.

4.3.4 On-Orbit

The AMS Payload will be operated on-orbit as specified in SSP 57113, “Payload Integration Agreement for Alpha Magnetic Spectrometer – 02”; SSP 57113A, “Payload Integration Agreement Increment Addendum for Alpha Magnetic Spectrometer – 02 (AMS-02)” and the appropriate IDRDs.

4.3.5 On-Orbit Post-Dock

Once the AMS is secured in the payload bay of the Space Shuttle for return, power will be connected to the experiment via the Remotely Operated Electrical Umbilical (ROEU) and the Auxiliary Power Control Units (APCUs) to allow for continued monitoring of experiment systems. Prior to deorbit prep activities, the AMS will be powered down for return.

4.3.6 Descent

If the mission is aborted prior to reaching the orbit, a barometric switch located on the AMS-02 will close the SFHe Tank nominal vent valve during re-entry to prevent intake

of air into the tank. If the mission is aborted after reaching the orbit and if time permits, this valve will be closed on-orbit prior to de-orbit if helium remains in the tank. In the event of such an abort, the SFHe Tank Nominal valve should be re-opened at TBD-1 hours post-landing to prevent rupture of the burst valves (for mission success purposes).

5.0 INTERFACES

The generic mechanical, electrical, avionics, thermal, and environmental interfaces of the AMS Payload are defined in the following documents: Part 2 of this ICD, SSP 57213, “Alpha Magnetic Spectrometer (AMS-02) Attached Payload Hardware Interface Control Document” and the MIP A-level ICDs. The PIB will provide the AMS Payload inputs to the ICDs and provide subsequent review support as required. No agreements will be made in this ICD that conflict with SSP 57213 or the MIP A-level ICDs.

5.1 STRUCTURAL/MECHANICAL INTERFACES

The AMS Experiment will interface with the PIB provided USS-02 and VC utilizing the mounting locations defined in Part 2 of this ICD.

5.2 CABLE INTERFACES

The AMS Experiment will interface with the PIB provided cabling utilizing the cables defined in Part 2 of this ICD.

5.3 SIGNAL INTERFACES

The AMS Experiment will interface with the STS provided Remotely Operated Electrical Umbilical (ROEU)/Payload Disconnect Assembly (PDA) and the ISS provided Umbilical Mechanism Assembly (UMA) utilizing the data interfaces defined in Part 2 of this ICD.

5.4 ELECTRICAL POWER INTERFACES

The AMS Experiment will utilize the power interfaces defined in Part 2 of this ICD.

5.5 FLUID INTERFACES

Not applicable.

5.6 SOFTWARE INTERFACES

The AMS Experiment will utilize the software interfaces defined in Part 2 of this ICD.

6.0 ENVIRONMENTAL ANALYSIS

Environmental analysis will be conducted to determine physical and functional interface compatibility of the AMS Payload. The specific analyses and responsibilities are described in the following sections. MIT will provide analytical inputs to the PIB to support these analyses.

The natural and induced environments are defined in SSP 57213 and the MIP A-level ICD.

All design, certification and integration activities will be accomplished in accordance with the AMS-02 Master Schedule which is updated periodically by the PIB.

A list of hardware and documentation deliverables is contained in Section 12.0.

6.1 STRUCTURAL LOADS AND DEFLECTIONS

The design requirements found in SSP 57213 and the MIP A-level ICD correspond to the ISS, Shuttle and USS-02 loading environments and are recommended as minimum conditions to which MIT should develop their preliminary design. Subsequent design will be based upon coupled dynamic and quasi-static analyses performed using updated AMS Experiment, USS-02, Shuttle and ISS models. MIT is responsible for assuring that the experiment is designed to be compatible with the ISS, Shuttle and USS-02 environments resulting from these analyses and any subsequent updates. The PIB is responsible for assuring that the interface forces and deflections (including thermal effects and manufacturing tolerances) do not exceed the limits specified in SSP 57213, the MIP A-level ICD and this ICD, based on analysis of the integrated system.

The PIB will provide an approach for AMS Payload strength verification and mathematical verification, and obtain MIT’s concurrence. These written plans for strength verification and mathematical model verification will be provided to the Payload Safety Review Panel (PSRP). Any AMS Payload deviation in the approach from ISSP and SSP requirements must be documented before the fact as a deviation with which the PIB has concurred. The results of structural verification testing by MIT as required by the JSC ISSP and SSP will be provided to the PIB.

The results of the ISS verification loads cycle and the SSP verification loads analysis will be used by the PIB to ensure that the interface loads and relative deflections are within the ISS, Orbiter and AMS Payload capability. The PIB and MIT are responsible for verifying the AMS Payload compatibility with these loads, and for verifying that the dynamic envelope (including thermal effects and manufacturing tolerances) does not exceed the allowable limits, as specified in SSP 57213 and the MIP A-level ICDs, based on the integrated system analyses.

Refer to the latest revision of JSC 28792, “Alpha Magnetic Spectrometer – 02 Structural Verification Plan for the Space Transportation System and the International Space Station “ for definition and products associated with the structural verification process.

The PIB developed models, analyses, and reports will conform to NSTS 32329, “Structural Integration Analyses Responsibility Definition for Space Shuttle Vehicle and Cargo Element Developers.”

6.2 THERMAL ENVIRONMENTS AND INTERFACES

The generic thermal design parameters used for integrated thermal analyses of the AMS Payload are provided in SSP 57213 and the MIP A-level ICDs. The mission unique requirements are defined in Part 2 of this ICD. The PIB is responsible for assuring that the AMS Payload is designed to be compatible with the ISS and Orbiter environments as specified in Part 2 of this ICD.

MIT will provide the most recent versions of the AMS thermal models to the PIB. The PIB will develop an integrated AMS Payload/Orbiter model and an integrated AMS Payload/ISS model and will perform the required integrated thermal analyses. The AMS Payload thermal reports containing the results of these analyses will be provided in the appropriate design review data package.

The PIB will provide preflight thermal predictions to MIT to be used for experiment and real time mission support. These analyses will utilize MIT provided mission timelines for power requirements and ISS attitudes.

6.3 ELECTROMAGNETIC INTERFERENCE (EMI) ELECTROMAGNETIC COMPATABILITY (EMC)

The PIB is responsible for assuring that the AMS Payload interfaces meet the induced electromagnetic Interference environment, and that the entire AMS Payload complies with the conductive and radiated emission requirements defined in SSP 57213, the MIP ICDs and part 2 of this ICD. The specific characteristics of the emission sources, if any, will be provided by the PIB. The PIB is responsible for assuring compliance with the design requirements for electrical bonding, circuit return isolation and grounding, and wire separation at the interface and within the AMS Payload where it affects the interface. MIT retains the responsibility for assuring that the AMS Experiment operates properly in the electromagnetic environment specified in Part 2 of this ICD.

6.4 SHOCK, RANDOM VIBRATION, AND ACOUSTIC ENVIRONMENTS

The PIB is responsible for verifying the compatibility of the AMS Payload with the Shuttle induced shock, random vibration, and acoustic environments defined in the MIP A-level ICD and Part 2 of this ICD. It is also responsible for verifying the compatibility at the AMS Payload with the ISS shock, random vibration and microgravity environments defined in SSP 57213.

6.5 COMMAND AND DATA, SOFTWARE, AND ELECTRICAL POWER

6.5.1 Command and Data Management Subsystem and Software

The PIB is responsible for assuring that the AMS Payload is designed to be compatible with the capabilities and constraints of the Shuttle and ISS data systems. Design requirements and guidelines for the payload are provided in Part 2 of this ICD. MIT will provide to the PIB sufficient information to allow the generation of MIP Annex 4 for command and data during the checkout of the AMS Payload while in the Orbiter and to coordinate the development of AMS Payload command and data requirements in ISS documentation while installed on the ISS.

6.5.2 Electrical Power

The PIB is responsible for assuring that the payload is designed to be compatible with the capabilities and constraints of the Space Station and Space Shuttle power systems.

Design requirements and guidelines for the payload are provided in Part 2 of this ICD. The PIB will perform a payload compatibility analysis for the power system. This analysis will include power, voltage drop, circuit breaker, and fuse compatibility between the payload requirements and the Space Station/Shuttle capability and constraints. The data, results, and updates will be provided to MIT in support of the flight readiness reviews.

6.6 MATERIALS

Materials and processes for integration hardware manufactured at JSC shall meet SE-M-0096, “General Specification for Materials and Processes Requirements for JSC controlled Payloads,” and the materials requirements of sections 208.3 and 209 of NSTS 1700.7B and NSTS 1700.7B ISS Addendum. Evaluation of materials for outgassing, flammability, corrosion, and stress corrosion cracking can be obtained from MSFC-HDBK-527/JSC-09604, “JSC GFE Materials Selection List and Materials Documentation Procedures,” and the Materials and Processes Technology Information System (MAPTIS) internet web site.

7.0 MISSION HARDWARE AND SOFTWARE

7.1 MISSION HARDWARE

7.1.1 PIB and MIT Provided Flight Hardware

The PIB and MIT provided flight hardware is identified in Table 7-1 and Table 7-2, respectively. The configuration and interface definition of the flight hardware supplied by the PIB is defined in Part 2 of this ICD.

MIT will identify to the PIB the location of subsystem temperature sensors on the payload equipment mounted on the USS-02, by joint agreement, and as defined in Part 2 of this ICD.

7.1.2 GSE and GHE

Table 7-3 and Table 7-4 identify the PIB and MIT provided GSE and GHE, respectively, that is required to support AMS Payload ground processing and testing.

7.2 INTEGRATION SOFTWARE

MIT will provide a subsystem instrumentation and command list to the PIB, which will contain display and control parameters relative to AMS Payload subsystems. The PIB will utilize this list in the development of command and data requirements in MIP Annex 4, SSP 57113 and SSP 57313.

TABLE 7-1 PIB PROVIDED FLIGHT HARDWARE

ITEMS	UNITS
* External Berthing Cue System (EBCS), and cables and brackets	1
* EVA (Extravehicular Activity) handrails/ Tether attach points	10 or less
* Flight Releasable Grapple Fixture (FRGF), and cables and brackets	1
* Portable Foot Restraints (PFR) Worksite Interface (WIF)	2 or less
* Power Video Grapple Fixture (PVGF), and cables and brackets	1
* ROEU/PDA, and cables and brackets	1
* Umbilical Mechanism Assembly (UMA) (Passive Half), and cables and brackets	1
Cryomagnet Vacuum Case (VC) (Flight Article)	1
Power Distribution Box (PDB)	1
Meteoroid and Orbital Debris (M/OD) shields	2
Payload Attach System (PAS) (Passive Half)	1
EVA Interface Panel (Interface to UMA)	1
Interface Panel A (Interface to ROEU)	1
Cabling from interface panels to J-Crate and PDB	–
DDRS –02 and associated cabling/interface cards	1
Trunnion scuff plates for deployable payload	4 (Part of USS-02)
Thermal Blankets	TBD-2
Unique Support Structure-02 (USS-02)	1
Monitoring and Control Computers (MCC)	2

* Items supplied by NASA STS or ISS and integrated into AMS Payload by the JSC PIB.

TABLE 7-2 MIT PROVIDED FLIGHT HARDWARE

ITEMS	UNITS
Transition Radiation Detector (TRD)	1
TRD Gas System	1
Upper and Lower Time-Of-Flight (TOF) Scintillator Assembly	1 each
AMS-02 Silicon Tracker Assembly	1
Tracker Alignment System (TAS)	1
Anti-Coincidence Counter (ACC)	1
Ring Imaging Cherenkov Counter (RICH)	1
Electromagnetic Calorimeter (ECAL)	1
Thermal Control System (TCS)	1
AMS Crew Operations Post (ACOP)	1
Experiment Avionics including Star Tracker	1

TABLE 7-3 PIB-PROVIDED GSE AND GHE

ITEMS	UNITS
VC Structural Test Article (STA)	1
Primary Support Stand (PSS)	1
Lower USS Support Fixture	1
Primary Lifting Fixture	1
Multi-purpose Lifting Fixture	1
Intermediate Support Fixtures	4
USS-02 Assembly Fixture	1
Special Test Equipment (STE) for structural testing	Multiple
* Neutral Buoyancy Laboratory (NBL) mockups	2
VC/Magnet Shipping Fixture	2

TABLE 7-4 MIT-PROVIDED GSE AND GHE

ITEMS	UNITS
Cryomagnet GSE	N/A
TRD GSE	N/A
TCS GSE	N/A
TCS STAs	TBD-3
GSE Dewar Lifting Sling	TBD-4
Experiment Electrical GSE	N/A
STA Cold Mass Replica	1
STA He Tank	1
STA Cryo System	1
Possible Magnet Operation Alert System	1
Possible Metal Detector	1
GSE Batteries	TBD-5
Shipping Containers	TBD-6

8.0 FLIGHT OPERATIONS

8.1 INTEGRATED TRAINING

MIT and PIB will support the Joint Integrated Simulations (JIS's) conducted by the SSP. MIT and PIB will also support the associated Joint Integrated Simulations Working Groups (JISWG's).

8.2 FLIGHT OPERATIONS CONTROL AND SUPPORT

8.2.1 Operations Procedures

The PIB and MIT will assist the SSP in the development of the Joint Operations Interface Procedures (JOIP's) for the Space Shuttle flights and will assist the ISS in the development of the operational procedures for the on-orbit operation on the ISS.

8.2.2 Flight Operations Support

The PIB will make provisions for MIT's representative(s) in the JSC Mission Control Center (MCC) CSR during the Space Shuttle flights that transport the AMS Payload. The PIB will provide representatives at the CSR during these flights to provide a contact for assessment of the in-flight performance of the AMS Payload.

AMS personnel will utilize the JSC POCC to support on-orbit AMS Payload checkout in the Orbiter, and installation and checkout on the ISS.

8.3 GROUND COMMAND AND CONTROL

After installation on the ISS and transition from the JSC POCC, ground command and control of the AMS Payload will originate from the MIT/CERN remote Payload Operations Control Center and will be routed through the Payload Operations Integration Center (POIC) at Marshall Space Flight Center (MSFC). The PIB will make provisions for the use of the POIC.

8.4 MAINTENANCE PROCEDURES

There is no planned maintenance for the AMS-02 external hardware. However, the PIB, MIT, and the STS/ISS representatives will jointly develop and agree on a maintenance procedure, should a real time situation requires one.

MIT shall provide maintenance procedures for ACOP, and the PIB shall develop maintenance procedures for DDRS-02. MIT will support PIB for inclusion of these procedures in the appropriate IDRD Annex 2.

8.5 PAYLOAD OPERATIONS WORKING GROUPS (POWG's)

MIT will support the PIB in Payload Operations Working Group (POWG) meetings conducted by the SSP to develop and refine operational scenarios and to resolve operational issues as the basis of flight rules, plans, and procedures addressing nominal and off-nominal situations.

8.6 OPERATIONS REVIEWS

MIT will assist the PIB to support the Station/Space Shuttle during reviews of flight rules, plans, and procedures for implementation of, and/or compatibility with, carrier and payload operations, requirements, and constraints.

8.7 FLIGHT PERFORMANCE EVALUATION

The PIB will perform a post-flight mission evaluation, and prepare integrated payload mission evaluation report of the AMS Payload.

9.0 SAFETY

9.1 GENERAL

The PIB is responsible for assuring the PSRP and the Ground Safety Review Panel (GSRP) that the AMS Payload and its GSE, including interfaces and operations, are safe. MIT shall provide any and all safety related input to the PIB for inclusion in the safety packages and support the safety reviews, as required. The AMS Payload and GSE design and operations must comply with the safety requirements defined in NSTS 1700.7B, NSTS 1700.7B ISS Addendum, 45 SW HB S-100/KHB 1700.7, and Part 2 of this ICD. Payload compliance with the Space Shuttle and Space Station safety requirements is assessed by the PIB through the SSP flight and ground safety reviews.

The PIB will provide hazard analyses of the AMS Payload, GHE, and GSE to support the payload safety reviews. The PIB will assess changes to the AMS Payload hardware affecting flight and ground safety against NSTS 1700.7B, NSTS 1700.7B ISS Addendum and 45 SW HB S-100/KHB 1700.7. These assessments will be presented to the PSRP and GSRP, as appropriate.

Any updates to the AMS Payload design since the last presentation to the safety review panels will be presented to the panels at the next AMS Payload safety review. This will include new waivers and Material Usage Agreements (MUA’s), applicable revised hazards, significant safety problems and anomalies. In conjunction with the Space Shuttle FOR, the integration hardware including systems and procedures, will be reviewed to highlight any safety concerns.

The PIB will prepare and submit a Certificate of Flight Readiness (COFR) for the AMS Payload to the ISSP and SSP.

9.2 DATA REQUIREMENTS

The PIB will submit to MIT a copy of all AMS Payload flight and ground safety review data packages required by the SSP.

To insure safety compatibility of the AMS Payload, the PIB-provided hazard analysis reports will identify potential failure/fault conditions associated with payload design or

operations, or payload utilization of Orbiter and Space Station services, that propagate across the interface to create a hazardous condition. Such conditions will include functional failure (loss of power, command, signal processing, thermal control, etc.) that could cause a payload hazard, failures of Space Station and/or Orbiter safety accommodations (caution and warning, safing, fire detection and suppression, etc.), and payload failures that could exceed the design criteria in Part 2 of this ICD. Assumptions made by the PIB with respect to Orbiter and/or Space Station services and operations associated with hazardous payload functions will be defined in the flight and ground safety data packages in accordance with NSTS 1700.7B, NSTS 1700.7B ISS Addendum and 45 SW HB S-100/KHB 1700.7.

The PIB and MIT will jointly identify in Part 2 of this ICD all power and signals (commands and monitoring) used for control of safety critical functions. For this input, payload safety critical functions are those electrical functions that must comply with the failure tolerance requirements of NSTS 1700.7B and NSTS 1700.7B ISS Addendum. Where subsystem equipment and/or wiring is involved in meeting the failure tolerance requirement, PIB will define such planned usage. Safety critical services required by the payload, in the areas of fault detection or emergency safing commands, must be obtained directly from SSP and the ISSP.

10.0 INTERFACE VERIFICATION AND TESTING

The PIB is responsible for the confirmation that all AMS Payload interface and safety requirements have been met. A combination of test, analyses, and inspections will be performed at the AMS Payload level to verify that the as-built hardware is in accordance with design requirements and/or constraints prior to delivery to the SSP. The PIB will perform analyses prior to physical integration of the AMS Experiment to verify that the total payload does not violate Shuttle and ISS interfaces, resources, and constraints.

MIT will provide the AMS Experiment assembly drawing numbers to the PIB for call up in the top payload installation/assembly drawing, making the AMS Payload drawing represent the entire cargo element. The PIB and MIT will prepare an AMS Payload assembly drawing to document the mission configuration. The PIB will provide updates to the assembly drawing as required to document the as-built configuration of the AMS Payload. MIT will provide certification to the PIB that the models provided to the PIB for USS-02 verification analyses (reference Section 6.1) represent the as-built, as-integrated AMS Experiment hardware installed on the USS-02 and VC.

AMS Payload-to-Space Shuttle (Level I) interface verification requirements to be accomplished at the launch site will be submitted by the PIB in the Operations and Maintenance Requirements and Specifications (OMRS) File II. Vol. II. This will include identifying safety critical requirements that require PIB approval of implementing KSC Work Authorization Documents (WAD's).

The PIB is responsible for verifying compatibility of AMS Payload interfaces as defined in Part 2 of this ICD. MIT will provide interface verification requirements to the PIB so that the PIB can generate MIP Annex 9, "Payload Verification Requirements." For any interfaces that cannot be verified, MIT will provide supporting rationale for non-verification.

MIT's input to MIP Annex 9 will also cover servicing and maintenance requirements. This will include identifying any safety critical requirements that require PIB approval of implementing KSC WAD's.

11.0 SCHEDULE

All activities and deliverables will be performed in accordance with the AMS-02 Master Schedule which will be updated periodically by the PIB. It will include schedule of design, certification, and integration for the AMS Payload. Dates indicated on the schedule will be directly related to the launch date of the AMS-02 flight. Due to the dynamic nature of the Space Shuttle and ISS manifest, the AMS-02 Master Schedule will be adjusted periodically per the current Space Shuttle and ISS manifest. Necessary changes to the planned dates will be coordinated between the PIB and MIT, but will not require formal Configuration Control Panel (CCP) approval.

12.0 DELIVERABLES LIST

12.1 LIST OF DELIVERABLES TO BE PROVIDED BY THE PIB

- Master Schedule
- KSC integration schedule
- Structural verification (modal and static test) schedule
- Flight hardware as listed in Table 7-1
- GSE and GHE as listed in Table 7-3
- Integration schematic for the circuitry grounding and shield grounding
- Verification Plan for the AMS Payload
- Flight Safety Data Packages
- Ground Safety Data Packages
- ICD for AMS Experiment interfaces to PIH
- A PDR data package
- A CDR data package
- Program Requirements Document/Project Management Plan (PRD/PMP)
- Mechanical drawings/schematics for the flight and ground equipment
- Electrical drawings/schematics for the flight and ground equipment
- Thermal Analysis Reports
- Structural Verification Plan for the AMS Payload
- Configuration Management Plan (CMP) for the AMS project
- Project Master List of Documents and Specifications for the AMS project
- Functional test procedures
- Mass Budget and Mass Properties Reports
- Top Assembly Drawing and Drawing Tree

12.2 LIST OF DELIVERABLES TO BE PROVIDED BY MIT

- Static bonding strap locations
- Integration schematics for AMS Experiment interface circuitry grounding and shield grounding
- Thermal requirements and thermal control system design
- AMS Experiment shipping container (only if necessary to ship AMS Experiment independent of the USS-02 and its related shipping containers)
- AMS Experiment and final assembly drawing

- Flight hardware as listed in Table 7-2
- GSE and GHE as listed in Table 7-4
- AMS bus monitor software
- AMS bus monitor card
- Structural analysis and test data for the secondary structure
- Materials list and data

APPENDIX A: TO BE DETERMINED/SUPPLIED ITEMS

TBD-1 Subject: Number of hours post-landing the SFHe Tank Nominal Valve should be re-opened.

TBD-2 Subject: Quantity of PIB supplied thermal blankets (Table 7-1)

TBD-3 Subject: Quantity of MIT supplied TCS STAs (Table 7-4)

TBD-4 Subject: Quantity of MIT supplied GSE Dewar Lifting Sling (Table 7-4)

TBD-5 Subject: Quantity of MIT supplied GSE Batteries (Table 7-4)

TBD-6 Subject: Quantity of MIT supplied Shipping Containers (Table 7-4)